TBI Comments on PRE Memo "Rationale for Changing X2 Objective"

The memorandum presented by the PREs entitled "Rationale for Changing X2 Objective" questions the importance of the very strong correlations between a number of covered fish species and Delta outflow (measured as X2). Its arguments reflect a poor understanding of the science and statistics that underlie using X2 as a metric for various aspects of estuarine habitat conditions. We briefly discuss the problems with the basic arguments presented, followed by comments on specific assertions in the text.

<u>PRE Rationale #1. The abundance:X2 relationships only exist for a few covered species and a few non-covered species</u>.

In other words, the relationships exist for almost all of those species we are most concerned about. The statistically significant, continuous abundance:X2 (or outflow) relationship has been documented over several decades worth of data for two covered species (longfin smelt and splittail; Jassby et al 1995; Kimmerer 2002; Rosenfield and Baxter 2007; Sommer et al. 2007; Kimmerer 2009). Importantly, the only covered species studied by these authors that did not display a statistically significant, <u>continuous</u>abundance:X2 (or outflow) relationship was Delta smelt. Various studies have shown an abundance:outflow relationship for Chinook salmon (e.g. Baker and Morhardt 2001; other research cited in Williams 2006) and Stevens and Miller (1983) demonstrated a strong relationship between Chinook success and Delta inflow (the authors of the present document acknowledge that inflow and outflow are strongly correlated). No one has studied the impact of outflow on abundance of sturgeon species.

<u>PRE Rationale #2. The abundance:X2 relationships have weakened over time</u>

There is simply no evidence of this for covered species. Kimmerer (2002) and Kimmerer et al (2009) find that the slope of the relationship between abundance and X2 is unchanged over time for either splittail or longfin smelt. Rosenfield and Baxter (2007) and Sommer et al (2007) also found no change in the slope of the X2: abundance relationship for longfin smelt. Each of these authors employed widely accepted statistical techniques to compare the slopes of the different lines and found that there was no difference in the slope of the line. The PRE memorandum's assertion to the contrary does not appear to be consistent with basic linear statistical techniques.

<u>PRE Rationale #3. There is no good mechanism to explain the abundance:x2 relationships</u>

Correlation is not causation, but it is an important clue that there is a causal mechanism. The absence of a definitive mechanism (or mechanisms) does not erase the extremely strong relationship between outflow and abundance. In fact, the existence of highly significant, durable, log:linear (or log:log) relationships between X2 and abundance strongly suggests a causal mechanism or, more likely, a suite of causal mechanisms. Kimmerer (2002b) has identified at least 11 mechanisms that may link Delta outflow and the abundance of species with statistically significant, continuous abundance:X2 (or outflow) relationships. In his 2002 paper, Kimmerer did not reject a foodweb stimulation mechanism for longfin smelt. Rosenfield and Baxter (2007) also found that the population data were consistent with a foodweb stimulation mechanism for longfin smelt. In their 2009 paper, Kimmerer et al. find that a physical habitat creation mechanism related to Delta outflow and the position of X2 may be the major driver of abundance relationships between X2 and American shad and striped bass. Furthermore, the x2:abundance relationships for longfin smelt and Crangon shrimp are consistent with the creation of additional habitats (the significant slopes have the same sign). In any case, absence of a definitive causal mechanism or set of causal mechanisms does not prevent us from using well-documented relationships to guide management actions. Understanding the causal mechanism associated with gravity was and is not a prerequisite to forming the resolve not to leap out of tall buildings. Nor does the evolution of strategies for flight by some species invalidate the basic observed effects of gravity.

PRE Rationale #4. The abundance:x2 relationships are non-linear and so there is no point in providing additional Delta outflow above a certain threshold or below a certain threshold

There is no evidence that the abundance:outflow relationships are anything but linear (meaning: mathematical transformations produce a continuous line). There is no statistical support at present for a threshold effect, either at the lower end of the spectrum of regulatory requirements for outflow (Collinsville) or the upper end (Roe Island). Previous statistical analyses that have purported to show non-linear relationships violate basic linear statistical techniques.

PRE Rationale #5.Other forces are impacting the covered species, so there is no reason to maintain Delta outflow standards.

There may very well be other factors (such as pollution) that contribute to the decline of one or more covered species. It is highly likely that multiple factors are contributing to population decline and that those factors (and their relative strengths) differ by species, by life stage, and from year to year. We welcome efforts to address all important factors. However, there is no other population driver that is as well-documented, powerful, long-lasting, or widespread (in terms of number of species affected) as the relationship between freshwater flow and fish species abundance. No credible argument based on the science or statistics has been advanced for relaxing the Delta outflow standards. Absent information about equally or more powerful and well-documented relationships or causal mechanisms that will demonstrably reduce the possibility of extinction or prolonged population depression, relaxing outflows at a time when so many species in this estuary whose abundance is associated with outflow are threatened with extinction is neither scientifically justifiable, morally responsible nor legally defensible.

Rationale for Changing X2 Objective

TBI comments in track changes format

Summary of Rationale for Elimination of the Roe Island Trigger:

The PREs have been working toward developing a future conditions water operations scenario for the BDCP intended to contribute to both biological and water supply needs. As part of this scenario, the PREs are proposing to eliminate, in all water-year types, the Roe Island trigger that exists in the current D1641 standard. We propose that this change occur both in the near term and long term BDCP implementation phases. Following is the rationale for this proposal. The following rationale is categorized as follows:

- X2, as an indicator of species abundance, correlates significantly with only 2 covered and 3 non native fish species;
- X2 is not a mechanism driving fish species abundance;
- The Roe Island standard is triggered infrequently but can be costly;
- Uncertainty regarding the benefit of X2 and other plausible mechanisms;
- Maximize efficiency of resources to better meet BDCP Planning Goals:

Generally speaking, correlations between X2 and fish abundance have been based on average X2 conditions between February and June and have not specifically identified any incremental benefits associated with the Roe Island standard. The high water cost associated with meeting a Roe Island standard can be used for greater water supply and environmental benefit given the substantial volume of water required to artificially maintain the Roe Island standard and the diminishing biological benefits resulting from such action.

Rationale:

1. X2, as an indicator of species abundance, correlates significantly with only 2 covered and 3 non native fish species: Or in other words, Kimmerer et al recently re-evaluated the relationship for 3 covered species and found strong statistical relationships for 2 of them. The authors did not re-evaluate the relationships for covered salmonids or sturgeon.

a. Kimmerer (2002) examined the relationship between X2 and abundance or survival indices for seven species of fish, bay shrimp, four groups of zooplankton, and concentrations of chlorophyll a. Kimmerer (2002 p. 42) selected the seasons for analysis based on larval and juvenile life stages for the fishes of interest, and the availability of data from the selected salinity ranges.

b. Kimmerer (2002) found a strong statistically significant log:linearcorrelation between X2 and abundance for 5 fish species: longfin smelt, Sacramento splittail, American shad, striped bassand starry flounder. The relationship between X2 and the abundance of Pacific herring and Delta smelt was not significant.

c. With the exception of American shad and striped bass survival, reduction in habitat associated with increasing X2 cannot explain the associated reductions in species abundance. Changes in longfin abundance could not be linked to the habitat associated

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Formatted: Comment Text, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers with X2 (Kimmerer et al 2009). Kimmerer et al's findings are mis-stated in several ways. Simply because the habitat volume-to- x2 relationship is not as large as the abundance-to-x2 relationship does not mean that it does not play a role. Using longfin as an example, Kimmerer et al state: "…although **increases in quantity of habitat may contribute**, the mechanism chiefly responsible for the X2 relationship for longfin smelt remains unknown." (**Emphasis added**). In other words, a relationship between x2 and longfin abundance is explicitly reaffirmed, as well as an acknowledgement that the flow-to-habitat relationship may contribute to the population response. There is no reason to expect that **one single** mechanism is responsible for the flow-to-abundance relationship for any one species (much less all species). Multiple mechanisms may (and probably are) at work for many species.

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In particular, for longfin smelt , Kimmerer 2002 failed to falsify the hypothesis that the correlation between food production and X2 could explain the longfin smelt population response. Note that Kimmerer (2002) and Kimmerer et al (2009) both find a signicant flow-to-abundance correlation for Bay shrimp and that the latter paper finds a correlation between flow and Crangon "habitat" (as measured by a crude two-dimensional habitat metric). Recent analysis by TBI shows that Delta outflow and longfin entrainment are highly correlated. It is very possible that the position of the salt field (X2) drives location of spawning territories and thus affects entrainment rates – CDFG presented a conceptual mode to this effect in their 2009 status review of longfin smelt. This is yet another process related to Delta outflow (X2) that supports a mechanistic (multiple-mechanistic) links between outflow and longfin populations.

2. X2 is not a mechanism driving fish species abundance:

a. X2 measures a single component of aquatic habitat, salinity. Aquatic habitat consists of many things, including organic compounds, temperature, turbidity, dissolved oxygen, contaminants, predator abundance, and prey density. X2 does not measure salinity; it measures the location of low-salinity (i.e., 2 ppt) habitat in the estuary. It is a metric that is strongly correlated with current freshwater outflow levels in relation to previous outflow levels (i.e., where the low-salinity habitat was immediately prior to the measurement). It is, therefore, valuable as an **indicator** that is used to **integrate** a variety of other habitat-related variables including the position of the salinity field, delta outflow, or flow through other parts of the estuary. The location of the salt mixing field is highly correlated across several orders of magnitude with the abundance of several fish species – this indicates that the position of X2, or something strongly correlated with that position (e.g. Delta outflow) is important to fish productivity in the estuary.

b. Mechanisms associated with abundance vary by species.

c. None of the mechanisms currently speculated to be important relate to western Delta-Suisun Bay salinity as measured by X2. In fact, with the possible exception of starry flounder, salinity itself appears to have relatively little to do with the mechanisms underpinning the relationship between X2 and fish abundance (Watson 2009). X2 is a

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measure of the position of the salinity field, whose position is related to several potential driving mechanisms behind estuarine fish species abundance – (see Kimmerer 2002b). X2 was always intended as an **indicator** of habitat conditions – it was never intended to reflect the habitat itself. Jassby et al. 1995 (p. 272) state: "Effective management of the estuary's biological resources requires **a sensitive indicator of the response to freshwater inflow** that has ecological significance, can be measured accurately and easily, and could be used as a "policy" variable to set standards for managing freshwater inflow. Positioning of the 2ppt … bottom salinity value along the axis of the estuary was examined **for that purpose**.

The 2ppt bottom salinity position (denoted by X2) has simple and significant statistical relationships with annual measures of many estuarine resources … The actual mechanisms are understood for only a few of these populations.

X2 also satisfies other recognized requirements of a **habitat indicator** and probably can be measured with greater accuracy and precision than alternative **habitat indicators** such as net freshwater inflow in to the estuary. The 2ppt value may not have special ecological significance for other estuaries (**in the Bay/Delta, it marks the locations of an estuarine turbidity maximum and peaks in the abundance of several estuarine organisms**) but the concept of using near-bottom isohaline position as a habitat indicator should be widely applicable" (emphasis added).

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d. For species like Sacramento Splittail and American shad, recognized mechanisms affecting abundance include floodplain inundation (splittail) (Kimmerer 2002a, Sommer et al 1997, 2002) and improved access to (tributary) spawning habitat (shad) (Kimmerer 2002). These conditions are usually associated with high inflow flooding events that occur in "wet-year" types. While mechanisms linking flows to abundance for these life stages of these fish species may have been identified, it is important to emphasize that study after study has found the flow-to-abundance relationships are log:linear. That means there is no suggestion or statistical evidence of a non-linear threshold effect.

e. For starry flounder a recognized mechanism is gravitational circulation (Moyle 2002), which is intensified by the high freshwater outflow that compresses the salinity gradient during "wet-year" types.

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f. There are no generally accepted mechanisms linking abundance of longfin smelt (Moyle 2002, Kimmerer 2002a) and American shad (Moyle 2002) to flow. Kimmerer 2002 does not reject hypotheses related to bottom up limitation of longfin smelt populations. Rosenfield and Baxter (2007) also find no reason to reject a food limitation mechanism behind the decline of longfin with decreasing Delta inflows – Crangon shrimp (a longfin prey item) have a strong abundance:flow relationship. Nor does Kimmerer et al (2009) reject the hypothesis that the habitat abundance:x2 relationship explains the fish abundance:x2 relationship.

3. Roe Island standard is triggered infrequently but can be costly:

a. The Roe Island/Port Chicago control point is triggered only when the mean EC at Roe Island during the last two weeks of the preceding month is 2.64 mmhos/cm or less, or the mean Delta outflow during the last three days of the preceding month is greater than 29,200 cfs.

b. The required number of days X2 must be maintained at Port Chicago/Roe Island is a function of the current month and the previous month's index (PMI) of unimpaired flow.

c. The required number of days to maintain X2 at Port Chicago/Roe Island is greater earlier in the season and when the previous month's inflow increases. Heavy precipitation or snowmelt at the end of one month can create a significant water cost in the next month, without any particular, concomitant, or demonstrable benefits for fish abundance or survival. To the contrary, the relationships between X2 and abundance are strong, continuous, and well-documented (unlike this assertion). The absence of a causal explanation does not invalidate these relationships, which are log:linear. Incremental changes in the order of magnitude of outflow (or X2, which has logarithmic properties) produce consistent proportional changes in the abundance of associated fish species. This assertion and the following arguments regarding the Roe Island trigger appear to be based solely on concerns regarding reallocation of water for environmental purposes away from consumptive uses, and not on any biological considerations.

d. Triggering of the Port Chicago/Roe Island standard produces only a small change in the location of X2, as illustrated below:

As X2 moves west, channel width and tidal force increases; therefore, ever increasing volumes of fresh water result in ever decreasing changes in the location of the X2 salinity zone.
e. The law of diminishing returns also applies to attempting to change population abundance with water. The relationship between longfin abundance and outflow, as an example, is calculated as follows:

Abundance = $10^{(-0.0487*X2+6.79)}$ From this formula, we can calculate the amount of additional Delta outflow associated with a 5% change in longfin smelt abundance as a function of the initial outflow. The higher the initial outflow, the more additional outflow associated with a 5% change in abundance. water associated with a predicted 5% change in longfin abundance, as displayed in the following graph:
Based on the median outflow of 32,000 cfs between 1955 and 2008, the volume of water associated with a mere 5% increase in longfin abundance would be approximately 500,000 acre-feet. Of all the species examined by Kimmerer, longfin appear the most sensitive to flow; so for the other fish species, the amount of additional flow associated with a 5% change in abundance would be even higher.

Maintaining the Roe Island standard beyond that supported by naturally occurring hydrology depletes upstream storage that could otherwise have been used to contribute to other Planning Goals. On the contrary, maintaining the Roe Island requirement more accurately reflects natural hydrology than the alteration of natural runoff patterns and amounts caused by large-scale water impoundment and diversions in and upstream of the Delta. Costs of maintaining this standard are perceived as high only because overall extractions are so high and the baseline conditions so poor for abundance of covered species. Also see comments on uses of upstream storage below.

4. Uncertainty regarding the benefit of X2 and other plausible mechanisms:

a. "Significant scientific uncertainty remains, however, about the specific linkages between salinity and fish species abundance and about how the aquatic ecosystem within the Delta and Suisun Bay might respond to changes in water flow management. Information is also needed about the relationships between river flow and,…, the effects of contaminants both in the water, and associated with suspended and bottom sediments" (Nichols 1998, USGS Fact Sheet 138-98).

b. In May, 2006, the CBDA convened an independent science panel to review the 2005 IEP POD Workplan and the 2005 IEP POD Synthesis Report. One conclusion of the review panel is directly related to the dominance of X2 in fish management in the estuary. This finding identifies a certain narrowness of perspective among fish management agencies, which the Panel described as follows:

"Excessive reliance on internal perspectives may inhibit creative thinking about complex scenarios (e.g., suites of factors that interact at multiple spatial and temporal scales) controlling the population dynamics of pelagic organisms. Due to the very challenging nature of the problems facing this managed ecosystem, a more open solicitation of ideas for creative solutions seems appropriate,.., The program relies too heavily on local perspectives and resources for problem analysis, research and solutions. This can give rise to a culture of common assumptions that impedes exploration of alternative possibilities."An interesting and thought-provoking comment, but not pertinent towhether the position of the X2 isohaline is strongly correlated with the abundance of numerous estuarine species. The relationships are based on science, and the use of the relationships to guide resource management is completely compatible with developing complex scenarios. Inclusion of this comment is perhaps meant to suggest that resource managers focus exclusively on outflow. This ignores the fact that resource management agencies regulate or otherwise implement numerous programs to address physical habitat, pollutant loadings and concentrations, exotic species, and other non-flow factors, as well as export operations, Delta inflow and upstream flow regimes – all areas where improved management is desirable, of course.

c. Kimmerer assessed the X2 relationship in terms of a regression that linked the log of the abundance/survival index to X2, to a factor assessing the importance of years before or after the establishment of the Asian clam (Corbula amurensis), and to a factor assessing the significance of an interaction between X2 and pre-/post-clam era. After the establishment of the Asian clam, the slope of abundance declines (flattens) indicating that changes in X2 are associated with smaller changes in abundance. This statement is completely incorrect for most species, and misinterprets the statistical analysis employed by both Kimmerer (2002) and Rosenfield and Baxter (2007). Table 4 of Kimmerer (2002) identifies where there are significant interactions in the X2-to-abundance relationship in the pre-clam post-clam comparison. A significant interaction indicates that the slope of the relationship has changed. Kimmerer found 3 such interactions (for *Delta smelt, Eurytemora affinis, and Neomysis mercedis*). Six other relationships – including that for longfin smelt -- showed no significant change in slope over the two periods. Rosenfield

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and Baxter (2007) analyzed this problem for longfin and found no change in the slope of the relationship for any dataset studied. Also, the R2 drops, indicating that less of the variation in abundance is explained by variation in X2, suggesting the increased importance of other factors in the post-clam years. Following is the change in correlation for longfin:
The memo's reliance on absolute R2 values as the sole relevant statistical value belies a poor understanding of statistics. The number of years post-clam is less than the number of years pre-clam – all else being equal, in a system where there is a mean or average trend, variance is expected to decrease with increasing sample size – statistics is based on this principle. Thus, it is not at all surprising that the relationship in the latter time-period would explain less of the variance. The fact that there is a statistical relationship at all with so few years in the latter dataset is actually a testament to the strength of the relationship.

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which except 2002 lie below the line of best fit of the post-clam years.

d. Kimmerer's regressions constitute the strongest published evidence for a relationship between the abundance of important fish species and X2 OR variables strongly related to X2. Actually, numerous other papers have made the same point, using different species and different datasets over time, including: Stevens and Miller (1983); Jassby et al (1995); Rosenfield and Baxter (2007); Sommer et al (2007), etc. etc.
It is important to bear in mind that although the regressions are statistically significant, they do not prove that X2 itself caused the abundance changes observed. As stated earlier, none of the mechanisms currently considered important relate to western Delta salinity as measured by X2.

e. The benefit of high outflows has been found to auto-correlate with inundation of floodplains and aquatic habitat, which can also be achieved through non-flow management actions such as increasing the frequency of inundation of the Yolo Bypass and other suitable floodplain habitat, expanding access to tidal brackish aquatic habitat within the Suisun Marsh, and other similar habitat enhancements. See below.

f. Inflow correlates with changes in species abundance as well or better than X2. In particular, significant changes in abundance can be demonstrated to associate with large, uncontrolled events (i.e. "wet-year" types). The likely mechanisms include conveyance and distribution of organic materials from floodplain inundation, improved access to spawning habitat, gravitational circulation, and dilution of contaminants, to name a few. What is the evidence for any mechanism of floodplain inundation affecting any fishes other than fall run Chinook salmon and Sacramento splittail? The relationship between "inflow" and positive access to spawning habitat is likely to be negligible for organisms that spawn in the western Delta or further to the west (e.g. longfin smelt, starry flounder). Gravitational circulation does not occur, to any great extent, upstream of the Delta. This mechanism is quite important west of the Delta – and it results from interaction with freshwater outflow. And contaminant dilution is an interesting concept but far from documented. Indeed, depending on the source of inflow, high inflows can increase contaminant loads.

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i. X2 is the location in km of the 2% near-bottom isohaline (2 practical salinity units, psu) relative to the Golden Gate Bridge.

ii. X2 is an indicator of and is tightly correlated with Bay-Delta inflows and outflows (Jassby et al1995). Net outflow (inflow – export – net in-Delta consumption) is the proximate cause for the position of X2, while inflow is the ultimate cause. Hence the high correlation between inflow-to-abundance and outflow (or X2)-to-abundance relationships.

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Delta inflow is about 80% of unimpaired flow, and is closely correlated with unimpaired flow (Kimmerer 2004 p 37, TBI 2003 p 3). Unimpaired flow is not natural flow (Enright 1998). Natural flows are lower than calculated unimpaired flows, although the two are often incorrectly assumed to be the same. Delta outflow has averaged about 70% of inflow since 1956 (Kimmerer 2004, p 37).

iii. There are tight statistical correlations between Delta inflow, Delta outflow and X2, regardless of species. The X2 metric is based on the log of Delta outflow, and Delta outflow and Delta inflow are very tightly correlated (Kimmerer 2004). Therefore, the relationship between X2 and species abundance, such as there is one, should be viewed as equally strong between inflow and abundance (Watson 2009). Therefore, determination of whether Delta outflow or Delta inflow is more closely associated with abundance must rely on a species by species consideration of mechanisms underlying abundance vs. flow relationships. Agreed with regard to consideration of mechanisms. Keep in mind thatorganisms are most likely to be affected by flows that occur where the species occurs. Longfin smelt, starry flounder, salmon and steelhead smolt, juvenile striped bass, adult splittail, and adult Delta smelt do not occur (or occur at very low frequency) where Delta inflow would be measured – they are much more abundant where delta outflow is measured. Other life stages (eg. Chinook salmon fry, spawning splittail) occur where inflow is measured and it is likely that inflow is the more relevant metric to success of **those** life stages.

g. It is more desirable to maintain hydrologic variability within the estuary than to artificially manage for conditions that can be met only through releases from upstream storage. The preparers of this memo are apparently unaware that natural hydrological variability, among other important ecological factors influenced by hydrology, has been radically altered by the development and operation of storage and diversions facilities in and upstream of the Delta.

h. Ammonium levels in the Sacramento River from Hood to Martinez are highly correlated with Delta inflow, outflow, and X2. This is to be expected when a consistent source of loading (in this case ammonia discharges from the Sacramento Regional Treatment Plant) is diluted by varying flows of water. However, ammonium concentrations are also rising on average due to increasing discharges from the Sacramento Regional Treatment Plant over time. Recent research by Dugdale suggests that elevated ammonium levels suppress phytoplankton blooms, particularly diatom blooms. The break point at which ammonium suppression of diatom blooms begins to relax is about .05 mg/l. The lower Sacramento River and Suisun Bay once reached such low levels of ammonium routinely during the spring and summer. However, low ammonium concentrations are now only reached during periods of high flow. Thus, ammonium suppression of the base of the food chain will be correlated with inflow, outflow, and X2. This hypothesis merits further investigation. However, the basis for the argument implies that there is some threshold effect, below which Delta outflows do not

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impact population abundances. Jassby et al (1995); Kimmerer (2002); Rosenfield and Baxter (2007); and Kimmerer et al (2009) demonstrate a log:linear relationship between outflow and abundance. It is a linear and continuous relationship. There is no statistical evidence or suggestion of a discontinuous relationship as suggested by the hypothesis above. Similarly, unless this memo are arguing that Delta smelt do not respond to high levels of ammonium, it is hard to understand why Delta smelt would not show the outflow-to-abundance relationship that other fish species show. This is particularly curious given that Delta smelt spend more of their life cycle in closer proximity to the source of the ammonium than any other fish species in this estuary. So, while ammonia may be a problem, it is doubtful that it is the only or main source of the multi-decade long decline in fish like longfin smelt, Chinook salmon, green sturgeon, etc. Nonetheless, as a precautionary measure, we would support efforts to reduce ammonia loading to the estuary.

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i. A complication to the ammonium/ flow/ phytoplankton linkage is the introduction of the Asian Clam *Corbula* in 1987. The clam appears to suppress diatom densities, particularly in the summer. However, even though diatom densities are lower than they were before 1987, low ammonium levels still appear capable of boosting diatom densities in the winter and spring – during the months February through June – key food supplies for species of concern. Since zooplankton abundance depends upon adequate supplies of phytoplankton, we would expect zooplankton to be correlated with phytoplankton levels and with ammonium. Such correlations exist. Moving higher up the food chain, longfin smelt FMWT abundance correlates better with spring ammonium concentrations in Suisun Bay than it does with X2.If this relationship is real then it should be possible to statistically extract the signal from that of X2 (or outflow). We are unaware of any published data to demonstrate such a signal to date.

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ii. If the existence of the X2 correlations with various species is simply a proxy correlation for ammonium correlations, then the appropriate response would be to reduce ammonia discharges into the estuary rather than to waste valuable water on dilution flows.This memo reflects a rather naïve view of nature where for every effect there is just one cause. If ammonium concentrations are the only cause of the decades long, orders of magnitude level declines in abundance of all associated fish species, then of course reduction of ammonium levels is called for and other measures are not necessary. However, given that such a wide variety of fish species demonstrate such a strong correlation with flows over a four-decade-long period, it is doubtful that ammonium is the only mechanism behind the X2-to-abundance relationships.

5. Maximize efficiency of resources to better meet BDCP Planning Goals:

a. "…the salinity standard [X2] is a rather crude management tool." IEP 1996And democracy is the worst of all political systems, except for all the others, according to Churchill. We look forward to the development of more sophisticated management tools that are based on equally or more powerful well-documented relationships or causal mechanisms.

b. As BDCP endeavors to develop ways to contribute to both our biological and water supply needs, it is incumbent upon us to not only explore new methods and approaches but also to examine the utility of the measures that have already been established to determine whether or not they are achieving their intended purposes, are still relevant, and represent an efficient use of our limited resources. Agreed, and we look forward to reassessing the reliance of export contractors on north to south water transfers in a highly stressed estuary experiencing global warming-induced changes, and evaluating the utility of alternative sources of water supply and demand management approaches in meeting the BDCP water supply goals.

Modification of Collinsville standard

Current standard for compliance at Collinsville in May and June of critical years is not consistent with analysis used to derive days of compliance.

Meeting the standard in May and June of critical years affects reservoir storage and releases and project diversions with questionable benefits in the Delta both now and in the future. Once again, outflow (X2)-to-abundance relationships are log-linear. There is no evidence that they are discontinuous or seriously non-linear. The meaning of this is that incremental increases in freshwater flow (decreases in X2) produce incremental increases in fish abundances.

Biological tradeoff between questionable benefits of May-June releases in critical years for pelagic fish versus definite adverse impacts on salmonids from reduced coldwater pool and flows to maintain stream temperature through late summer and fall. Given that May and June are the beginning of the period when cold water is released for protection of salmonids, it would appear that operating to improve coldwater releases would likely result in maintaining X2 in the delta during this period.

Review biological basis for May-June Collinsville standard and develop approaches that relax the standard in drier years based on streamflow runoff index, reservoir storage levels, or some combination of those two factors.